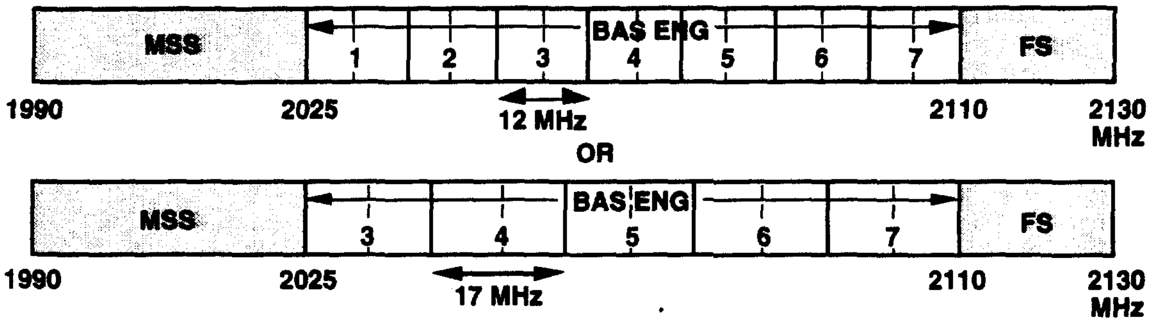
operations. The plan makes use of digital technology to afford increased spectrum efficiency for BAS operations. Recent progress in digital video compression technology and present commercial availability of the equipment make this plan both viable and affordable today. Digital technology offers BAS the real possibility of creating additional ENG channels, improving transmission link performance, and increasing overall audio-video quality over a wide range of conditions.

Two rechannelization options are shown below. These options are described more fully in Section IV below. The first option provides for seven channels of 12 MHz bandwidths (first channel occupies 13 MHz bandwidth) that could be further rechannelized to fourteen channels of 6 MHz bandwidths (6.5 MHz bandwidth in the first channel pair). The second option consists of five channels of 17 MHz bandwidths that could be further rechannelized to 10 channels of 8.5 MHz bandwidth.



COMSAT and Hughes 2 GHz Spectrum Recommendation

As we demonstrate in Section III below, digital technology makes it possible to transmit "contribution quality" signals[1] in 6, 8.5, or 12 MHz channels instead of the 17 MHz required for analog FM transmission. Digital compression and modulation equipment are commercially available and in use today for SNG and other TV distribution applications. This same digital equipment can be used to retrofit existing fleets of ENG vans and studio receive sites over the next few years.

II. Current Technology and Operations Employed in BAS ENG

General

Under Title 47 C.F.R. Part 74, Subpart F - Television Broadcast Auxilliary Stations' licenses for TV pickup stations, also known as ENG, are issued to a television broadcast station or television broadcast network entity and certain other TV facilities.

ENG Frequency Assignments

The current frequency assignments for ENG are set forth in Section 74.602 (i.e., television pickup and broadcast network-entities may use 120 MHz of spectrum in Band "A," 1990 - 2110 MHz, as well as 250 MHz of spectrum in Band "B," 6875 - 7125 MHz, and some additional higher frequency bands). The Band "A" channels are numbered 1 to 7 and each channel occupies 17 MHz in bandwidth (except channel 1, which occupies 18 MHz).

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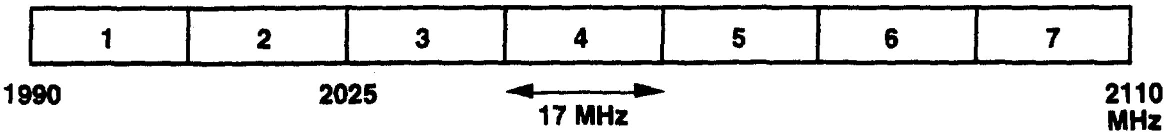
[1] See 2 GHz Order n.45. Contribution quality signal, as defined for ENG applications, is a high quality audio-video signal for direct input into television broadcast.

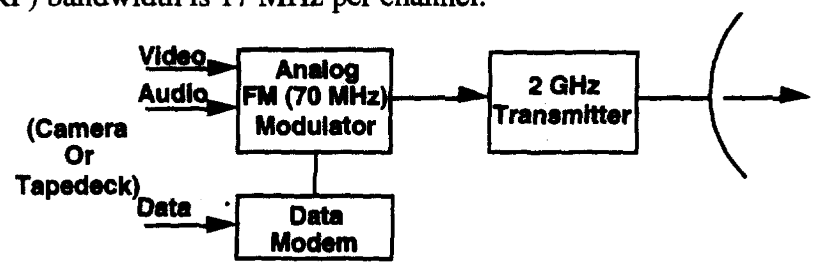


Current BAS Band "A" Frequency Plan

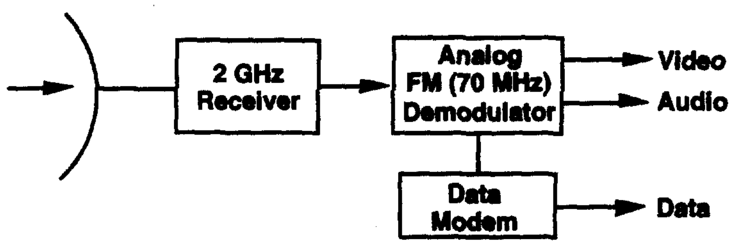
Description of Current Analog BAS ENG Mode of Operation

Transportable ENG vans require direct line-of-sight to the receive site and are used for on-location coverage of news events or interviews and live-action video during sports and entertainment events. SNG vans are used for long distance transmission, when the line-of-sight mode is not available.

The following diagram portrays the key ENG van and receive site components. Analog video and audio inputs (and/or data) feed an FM modulator at the ENG van. The 70 MHz intermediate frequency modulator output is upconverted to the 2 GHz range, amplified, and transmitted to the receive site at a maximum of 12 watts (10.8 dBW). The resulting radio frequency (RF) bandwidth is 17 MHz per channel.



ENG Van (Transmit)



TV Station (Receive)

While the FCC's decision in the 2 GHz Order reduces each of the 17 and 18 MHz channels to 15 MHz, the Commission should consider alternative, more spectrum efficient channelization plans afforded by digital technology for BAS operations.

III. Available Digital Technology Provides More Efficient Spectrum Utilization

In the recent DTV Order, the Commission has articulated the advantages afforded by digital technology - both in terms of services and efficient spectrum management. The Commission is clearly aware of the prolific availability of digital equipment, since it has made the decision to expedite the introduction of digital television for over-the-air broadcasting and to end NTSC service by 2006. The Commission, in allocating a 6 MHz bandwidth for each of these digital television signals, recognizes the technical feasibility of transmitting such a digital signal within a narrow RF bandwidth. The same digital compression technology is being adopted for numerous applications, including SNG for domestic and international program distribution. Because many of the requirements for SNG apply directly to ENG, much of the same equipment can be applied to ENG environments.

SNG versus ENG

A number of broadcast networks are now transitioning from analog to digital TV transmission for their SNG links to take advantage of spectrum efficiency and the resulting savings in transmission cost. In conventional analog FM TV satellite transmission, an *entire 27 MHz satellite Ku-band transponder* is typically used to transmit one TV channel. By using video compression and digital modulation, such as Quadrature Phase Shift Keying (QPSK), for digital TV transmission to a satellite, only a *partial transponder*, nominally 6 to 8 MHz, is required to transmit a single channel to a satellite. Alternatively, by using this same digital technology, *multiple TV channels*, rather than just one channel, can be transmitted over a satellite transponder. In either case, the spectrum efficiency resulting from digital TV transmission yields significant cost benefits to broadcast networks, since they are charged for the *amount of bandwidth* used on satellite transponders. For example, a 27 MHz Ku-band transponder on a Hughes Galaxy satellite costs approximately $2M per year. A broadcast network can transmit 4 digital TV channels in the same bandwidth previously used to transmit one channel using analog FM transmission. This effectively results in a 75% cost savings to the broadcast networks on the space segment. The current adoption of digital television for SNG demonstrates that when cost savings provide an incentive to utilize this technology, broadcast networks have readily embraced it. This notion was confirmed in an interview with the CBS News general manager of operations, Frank Governale, who stated, "It worked out for both of us [CBS and affiliates]. The network saved money, and we pushed some of those [space segment] savings onto the affiliates, which allowed them to pay for the IRDs [digital codec receiver]." (*Broadcasting & Cable*, August 26, 1996) What the SNG example demonstrates is that if BAS ENG is required to operate in 85 MHz of spectrum (2025 - 2110 MHz), TV stations can adjust accordingly through digital technology application.

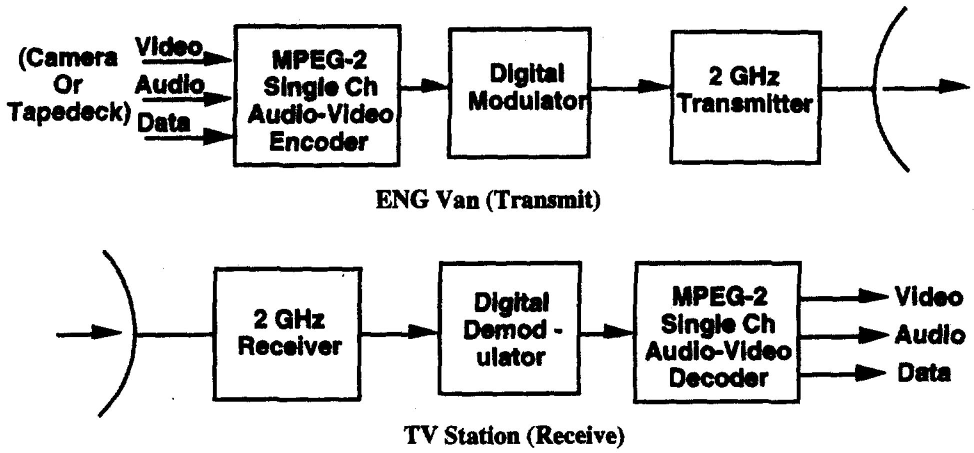
Digial Video Compression and Transmission Technology

Major advances in digital video compression technology have occurred in the past two years. At the present time, numerous companies provide a range of digital video solutions (codecs, modems, exciters, etc.) that support a number of video formats at varying bit rates and picture qualities for a broad range of applications from Direct Broadcast Satellite (DBS) to Digital Cable TV. All of these applications benefit from the advantages of digital video compression and transmission: (1) increased spectrum efficiency, (2) high audio-video picture quality, and (3) robustness in error prone environments. Digital television transmission can mitigate the effects of interference, fading, and multipath reception problems typical in analog FM transmission. At the same time, digital compression and transmission afford more efficient use of available spectrum, while maintaining a high audio-video quality signal.

(1) Increased Spectrum Efficiency

Digital video compression and transmission afford increased spectrum efficiency. MPEG-2 is the prevailing digital audio-video compression standard that can provide contribution quality digital video. It is flexible because it supports many profiles and levels and adjustable bit rates that can be configured for virtually any digital video application, including HDTV. There are a large number of manufacturers supporting both the MPEG-2

4:2:0 and 4:2:2 profiles at main level that can support a range of bit rates and picture quality requirements. Using digital modulation schemes, in conjunction with MPEG-2 and forward error correction, each ENG television channel can easily fit within 6 to 12 MHz bandwidths.

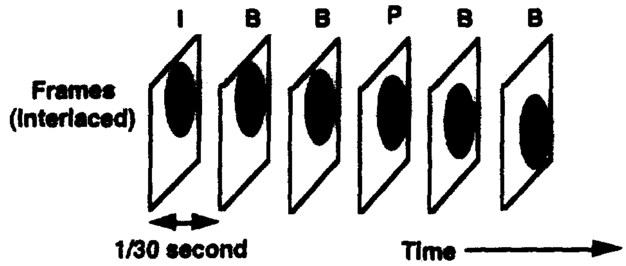


MPEG-2 is a digital audio-video coding standard developed by the ISO/IEC/JTC1/SC29/WG11 committee to address applications that require all-digital transmission of broadcast quality[2] and contribution quality video. It became an International Standard (IS) in November 1994. Since then, a number of companies provide commercially available MPEG-2 codecs, including General Instruments, Divicom, Tiernan, Wegener, Sony, Thomson, Scientific Atlanta, Phillips, and many others, for a myriad of applications, including DBS, digital satellite news gathering, program backhaul over satellite, and digital TV over cable.

MPEG-2 was developed with the goal of providing broadcast and contribution quality video at relatively moderate bit rates while ensuring robust transmission over a number of different mediums, including noisy environments, such as terrestrial microwave. The digital video compression results from eliminating the spatial and temporal redundancy that is inherent in video signals. In addition, MPEG-2 also incorporates aspects of the human visual system model to provide minimal artifacts virtually imperceptible to the human visual system while maintaining high compression.

A video signal is essentially a sequence of time varying images. After the analog video signal is digitized, the resulting digital video signal has a spatial resolution of 720 x 480 pixels per frame and a temporal resolution of 30 interlaced frames per second (or 60 fields per second), in the example of CCIR-601 format for the U.S. *Spatial* redundancy occurs because neighboring pixels in each frame of a video signal are related and, therefore, have some degree of correlation. *Temporal* redundancy occurs because consecutive frames in a video sequence, in the absence of a scene cut, are also correlated and have a high degree of similarity, since they are only sampled at 1/30 second apart from each other.

[2] Broadcast quality may be defined as the quality picture obtainable consistent with the circumstances surrounding the event to be televised, and that which will satisfy viewer requirements. K. Blair Benson, Television Engineering Handbook (New York: McGraw Hill, Inc., 1986), p. 14.87.



The spatial and temporal redundancies are eliminated using a hybrid discrete cosine transform (DCT) and motion compensation algorithm. In the video sequence, three types of frames are identified: Intra (I), Predicted (P), and Bidirectional (B). The I frames are coded without reference to any other frames, using DCTs to eliminate spatial redundancy. The P and B frames are coded, using the motion compensation-based prediction technique, in which content in neighboring frames are matched and the displacement motion vectors are coded (along with a measure of the prediction error) to eliminate temporal redundancy. The P frames apply forward motion prediction, whereas B frames apply bidirectional motion prediction. Since the human visual system does not treat all the visual information with equal sensitivity, techniques such as quantizing the high spatial frequencies more heavily than the low spatial frequencies, can still lead to a perceptually very high quality video signal. In addition to the standard techniques used in coding moving images, MPEG-2 also handles the special case of interlaced video, which is the scanning pattern used in analog TV currently. It, therefore, has become the predominant compression standard for efficient coding of interlaced video.

In most cases, each of the TV channels used in the ENG environment can be encoded at 6 to 8.5 Mbps to provide a high audio-video quality signal. A single channel of compressed audio and video at those bit rates can easily fit within 6 MHz bandwidth [Example: Wegener *MPEG-2 Main Profile@Main Level 4:2:0 codec (also referred to as MPEG-2 4:2:0 codec)*, QPSK modulation, FEC: Rate 3/4 Convolutional coding, 188/204 Reed Solomon]. This results in potentially accommodating 14 channels in the 85 MHz of spectrum at 2025 - 2110 MHz and reflects one of many possible rechannelization plans.

(2) High Audio-Video Quality (Contribution Quality)

Digital video compression and transmission can provide a contribution quality signal. By converting to digital format, a high audio-video quality signal can be maintained through multiple generation recordings and multiple transmissions using techniques such as image processing, noise filtering, and error correction. This is not possible in analog format. MPEG-2 4:2:0 codecs provide a sufficiently high quality signal for most digital video applications. Video compression and transmission equipment are configurable to readily accommodate different programmable data rates best suited to the program material and transmission environment. The result is that transmission bandwidths can be dynamically changed for any news gathering application to achieve the highest audio-video quality for the specific program material. Broadcast networks, such as CBS, CNN,and NBC, are using *MPEG-2 4:2:0 codecs* for their SNG applications and have expressed much satisfaction with these codecs. John Frazee, CBS News vice president of news services, comments on the Tiernan MPEG-2 4:2:0 codecs: "After our experience in Europe, we decided it was ready to deploy here. It's a good picture – I don't think the average civilian, or even the average television person would know the difference." (*Broadcasting & Cable*, August 26, 1996). For the 1996 Republican National Convention in San Diego, CBS used six Tiernan encoders and Comstream QPSK modulators to compress and transmit six digital compressed video streams, each encoded at *8.4 Mbps to obtain high audio-video quality pictures.* In the small number of cases where additional chroma information is required, *MPEG-2 4:2:2 high profile at main level codecs (also known as professional profile codecs or MPEG-2 4:2:2 codecs*) are available at the present time. Many of the same companies providing MPEG-2 4:2:0 codecs were also displaying their MPEG-2 4:2:2 codecs at the NAB '97 show in Las Vegas. Even using these professional profile codecs, a single television channel can still be transmitted within 12 MHz bandwidth from an ENG van. [For example, a Sony Beta SX codec (MPEG-2 4:2:2) which has an encoded output bit rate of 21 Mbps modulated with either 16-QAM or 8-PSK digital modulation can easily fit within 12 MHz bandwidth.]

In summary, digital video compression affords increased spectrum efficiency without compromising contribution quality video for ENG applications. Thus, the 85 MHz of spectrum at 2025 - 2110 MHz provides sufficient bandwidth to accommodate flexible spectrum efficient rechannelization plans, using digital technology in markets where necessary.

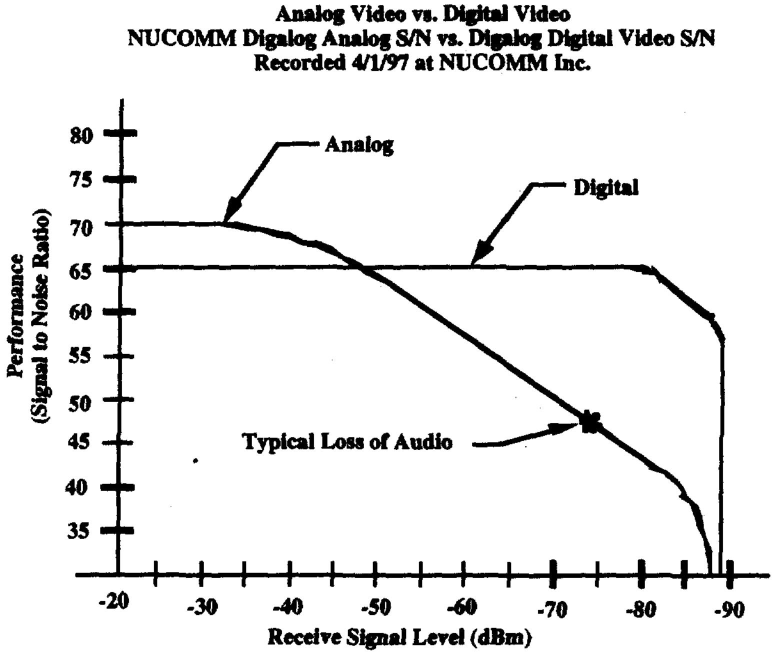
(3) Robustness in Error Prone Environments

Digital video transmission is more robust than analog FM television transmission. It is more robust because digital modulation and forward error correction techniques allow much greater tolerance in error prone environments and allow transmission for longer distances without picture quality degradation.

Digital modulation is a technique used to transmit baseband digital information over a bandpass channel. QPSK is a common modulation technique for satellite transmission due to its power spectral efficiency. Because of its wide use for digital satellite transmissions, QPSK modulators are readily available and can also be used for digital microwave terrestrial transmission. In QPSK modulation the phase of the carrier is changed in accordance with two bits of baseband digital information known as a symbol. The carrier phase is shifted by $\pi/2$ for each bit change resulting in four possible phase states: 0, $\pi/2$, π, and $3\pi/2$ degrees. Thus a carrier with 0 degree phase change relative to the unmodulated signal may correspond to a bit pattern of 00; $\pi/2$ phase to 01; π phase to 10; and $3\pi/2$ phase to 11. Detection theory is used to determine which of the four phase states that the modulated digital information within the transmitted signal lies in to recover the symbols at the receive site. The resulting baseband signal is a concatenation of each of these detected symbols.

Error correction coding is also commonly used in digital transmissions to improve the signal quality. Two common features of error correction techniques are structured redundancy and noise averaging. Structured redundancy is a method of inserting extra or redundant symbols into the information message. Noise averaging is obtained by making the redundant symbols depend on a span of several information symbols being in error to cause an entire block error. Therefore, this averaging technique spreads the noise across the length of symbols in the block resulting in a decrease of error rate with increasing block length. Convolutional and Reed-Solomon coding are two common inner and outer error correction techniques. Interleaving between the two coding steps provides powerful protection against burst errors. This interleaving technique is particularly useful in terrestrial applications where burst events such as ignition noise are prevalent. When digital modulation is coupled with error correction techniques, the digital signal becomes very robust and easier to recover than analog signal transmission.

These digital techniques mitigate the effects of interference and multipath reception problems common in analog ENG transmission environments, such as the typical scenario that Society of Broadcast Engineers (SBE) described in their 1995 filing: "less-than-perfect ENG paths shooting through foliage or bouncing off an available high-rise building in order to establish a feed to the closest available ENG receive site".[3] In analog transmission, these techniques cannot be used. When an analog signal is transmitted in hostile propagation environments, it can easily get distorted resulting in actual information getting lost. The figure below shows that with digital transmission, a high constant audio-video quality can be sustained, whereas with analog transmission, the signal degrades and the picture quality deteriorates when the receive signal level is reduced. This demonstrates that digital ENG links can operate over longer and more difficult paths than analog ENG links.



(Source: Dr. John B. Payne III, President, NUCOMM Inc., an ENG equipment manufacturer, Presentation in Las Vegas, April 8-9, 1997)

Digital hardware is currently available and can be used for ENG

Digital video compression and transmission equipment is a current reality. The table below depicts examples of the broad, current deployment of digital technology in the United States. Digital equipment manufacturers offer a variety of digital video codec products, some of which implement proprietary algorithms, some of which comply with the MPEG-2 standard, and others that accomodate both.

[3] See SBE Comments ET Docket 95-18 of May 5, 1995, paragraph 9.8.

Application	User	Digital Codec Manufacturer
Direct Broadcast Service (DBS)	Hughes DIRECTV Echostar Primestar Alphastar	General Instruments Divicom General Instruments TVComm
Digital Cable TV	TCI	General Instruments / IMEDIA
Digital Fixed Service (7 GHz Intercity Relay)	USSB	General Instruments
Satellite / Cable Backhaul	HBO	General Instruments
	Family Channel Weather Channel	Scientific Atlanta
Digital Satellite News Gathering	CBS NBC CNN	Tiernan Wegener Wegener

In addition, INTELSAT is promoting the growth of compressed digital video transmission services by inviting manufacturers of video compression equipment to interoperability tests conducted at the INTELSAT Technical Laboratories. The test program was undertaken to resolve equipment (in)compatibility issues that INTELSAT had received from the Inter-Union Satellite Operations Group (ISOG)--which represents large broadcasters and INTELSAT Signatories worldwide. The focus of these tests is primarily on single-channel-per-carrier (SCPC) audio-video transmission used for SNG applications. INTELSAT has already conducted three rounds of interoperability tests in the past two years, with the most recent test conducted February 24 to March 4, 1997. Ten equipment manufacturers participated in the latest tests: California Microwave/STS, Divicom, DMV/NDS, General Instruments, Scientific Atlanta, Tadiran, Tandberg, Thomson, Tiernan, and Wegener. The following performance parameters were chosen to imply interoperation among codecs: (1) presence of acceptable video, (2) presence of acceptable audio, (3) automatic retrieval of MPEG-PSI, (4) subjective evaluation of lip sync, and (5) objective measurement of lip sync. According to the latest INTELSAT Test Report, "The results, in general, are very encouraging and demonstrate which coders and IRDs will 'plug and play' at data rates which might be appropriate to various applications. The measurements performed through the INTELSAT VII simulator showed non degradation of performance for the parameter sets chosen (6 MSPS [Mega-symbols per second], rate 3/4 [FEC], PAL [and NTSC])." According to the INTELSAT tests, less than 8 MHz bandwidth is required to transmit a compressed digital audio-video signal to yield a high quality signal ("non degradation of performance"). These tests have significantly helped news agencies solve technical difficulties to ensure interoperability of different manufacturer's digital equipment for satellite transmission. Frank Governale, CBS News general manager of operations, acknowledged that their selection of Tiernan was based on its top-three performance in these INTELSAT's MPEG-2 interoperability tests last spring. (*Broadcasting & Cable*, August, 26, 1996)

Current digital equipment employed in SNG environments can be readily used in ENG environments. ENG equipment has special physical requirements; in particular, the equipment must be small, portable, and rugged. Advances in recent years have been made to allow digital equipment to work in even these rugged environments. The best example is, again, the adoption of digital equipment for SNG environments. Since the SNG environment is similar, if not identical to ENG environments, the same digital codec and modem equipment can be incorporated in ENG environments. The only distinction between the two systems is that SNG transmits to a satellite, while ENG transmits to a terrestrial receive station. In summary, digital transmission is now employed in SNG environments to increase spectrum efficiency; it can also be employed in ENG environments for same purpose.

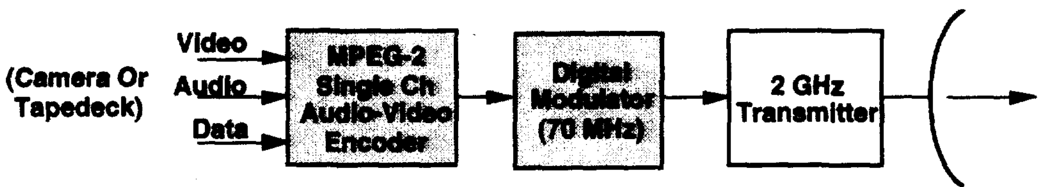
IV. Transitioning From Analog To Digital TV For BAS ENG

As noted in Section II, the steps needed to convert ENG equipment to handle digital TV transmissions are straightforward. A number of choices are available in the detailed engineering of any program for updating the ENG vans and receive sites for digital TV transmissions; in principle, however, the major requirements are fairly simple.

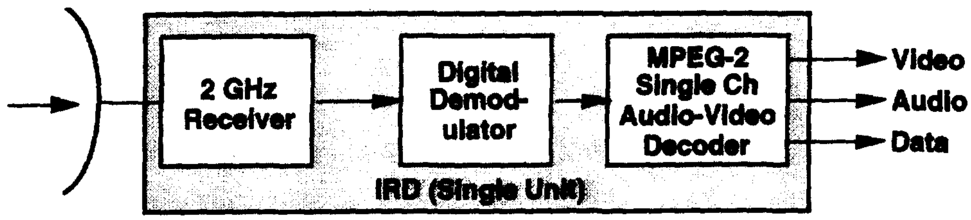
Equipment

Minimal "new" equipment is required for TV stations to convert their ENG link to digital video transmission. In essence, at the ENG van transmit site, the major critical piece of equipment needing replacement is the analog FM modulator. It would be replaced by a single-channel-per-carrier MPEG-2 encoder and a QPSK modulator, which includes forward error correction capabilities. These additional units are noted by the shaded boxes in the figure shown below. The encoders and modulators are quite flexible and can be configured to the appropriate bit rate and error correction code rate best suited to the environment in which the ENG operates. In many instances, manufacturers currently supplying MPEG-2 encoders to broadcast networks for satellite news gathering applications provide an integrated system which has a digital encoder physically connected to a QPSK modulator to conserve rack space in a van. In the cases where an ENG van has a Heterodyne type 2 GHz ENG transmitter, the same transmitter can still be used in the digital system. In the alternative case, where an ENG van has a Direct Modulation type transmitter, the transmitter would need to be upgraded to a stand-alone 2 GHz upconverter, but the power amplifer may still be used in the digital system.

The receive stations require only an Integrated Receiver Decoder (IRD) which combines the receiver, digital (QPSK) demodulator, and MPEG-2 decoding functions, rather than the analog receiver, FM demodulator and converter units. Virtually no modification would be required to these existing IRDs, currently used in SNG operations. The IRDs have the capability of tuning to frequencies in L-band (and on up into the 2 GHz spectrum) and adapting to variable RF bandwidths that result from different encoded bit rates employed at the ENG site.



ENG Van (Transmit)



TV Station (Receive)

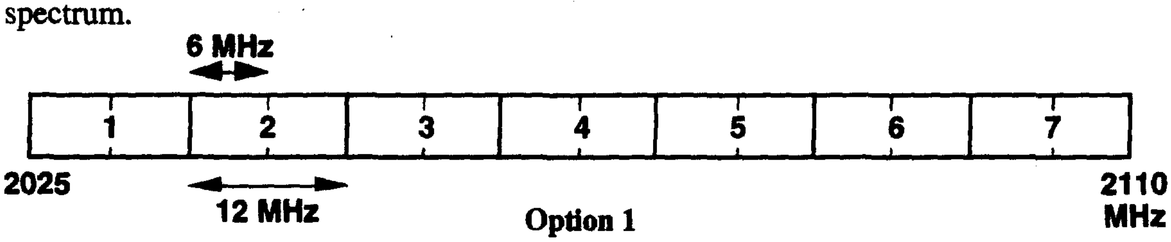
In the cases where TV stations predominately have analog equipment (tapedecks, cameras, editors, etc.), most digital codec equipment has analog inputs and outputs that can interface with these existing analog equipment to ease the transition to an all digital system and, if necessary, to convert only the transmission link to digital.

However, a growing number of TV stations are already converting parts of their news gathering system to incorporate digital equipment, such as digital cameras, tapedecks, and editors. In some of these cases, the only aspect of the news gathering system still in analog mode is the transmission link from the ENG van to the receive site. An example is WPGH-TV station in Pittsburgh, Pennsylvania, which will complete its construction of a digital state of the art newsroom system and studio in August 1997. "A Newstar newsroom system interfaces with four Tektronix Editstar non-linear editing workstations and the two Tektronix Profiles. The newsroom also is equipped with two Harris ENG trucks, 8 DVCPRO camcorders and a WSI weather system." (*Broadcasting & Cable*, April 9, 1997) In these cases, the conversion to a *complete* digital TV system becomes even more simple.

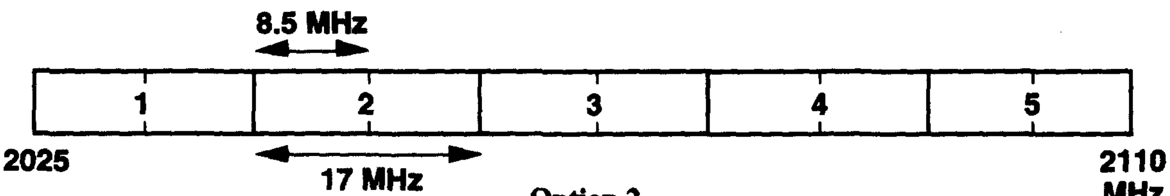
This additional equipment can be easily incorporated into a typical capital expense budget, in which the equipment can be amortized over some number of years, making it affordable for individual TV stations. For example, it could be added when the station replaces or upgrades obselete ENG electronics suites. An informal survey of manufacturers of digital compression equipment at the recent NAB Convention suggests that unit costs for this equipment will decline rapidly as volume increases.

Possible Channelization Plans

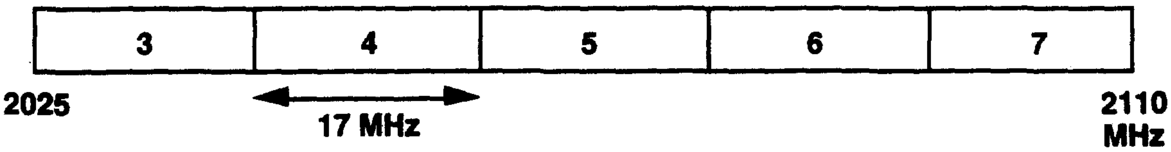
If the Commission limits the spectrum for BAS ENG operations to the 2025 - 2110 MHz band, there are a number of technically viable options for channelizing this spectrum. The figure below shows two possible ENG frequency plans feasible within the 85 MHz of spectrum.



Option 1



Option 2



Current BAS Band "A" Frequency Plan

In the first option, the 85 MHz of spectrum can be channelized so that at least the seven channel capacity can be maintained. Each digital channel could either occupy 6 or 12 MHz. Since, in most cases, a 6 MHz digitally compressed video signal can still provide sufficient video quality for ENG, the spectrum can be further divided to support a 14 channel capacity. However, in cases requiring more bandwidth than 6 MHz, two adjacent 6 MHz channels (12 MHz) could be allocated to TV stations. This may be foreseeable in future situations requiring additional capacity for 4:2:2 encoding or HDTV transmission.

In the second option, the 85 MHz reallocation can be channelized to support 5 to 10 channels, depending on whether the channel is digitally encoded to 8.5 MHz or whether the channel continues to support transmission of analog FM TV, thus occupying 17 MHz. This channelization plan would allow the broadcasters some flexibility in retaining analog FM transmission and deferring, for whatever reason, conversion to digital transmission for smaller stations in major markets or in TV markets that are less demanding and not occupying the full 120 MHz of spectrum. This would also allow larger stations in the top 10 markets to opt for conversion to digital ENG links early --roughly on par with the schedule that the Commission has established for DTV format. The inherent flexibility of 8.5 MHz becomes apparent once one considers that this bandwidth is exactly half of the standard 17 MHz used by ENG. Therefore, TV stations wishing to retain analog FM equipment and operations can use a double 8.5 MHz channel assignment, which corresponds *exactly* with the current FCC Band "A" ENG frequency plan for channels A03 to A07. TV stations planning near-term conversion to an all-digital ENG operation would transmit on an 8.5 MHz channel spacing. This plan would allow an ENG frequency coordinator in a given urban area the flexibility to assign the appropriate single 8.5 MHz or double 8.5 MHz channel to a given TV station. ENG receive sites, wishing to retain only FM operations, could maintain their current analog equipment, as long as they operate only on the current Band "A" ENG channels 3 through 7. Similar to the 6/12 MHz channelization plan described before, this plan also gives the flexibility of utilizing the 17 MHz for digital transmission, if TV stations require additional bandwidth for expanding to accommodate 4:2:2 encoding or HDTV at a later time.

In addition, even further channel capacity can be provided by means of exploiting the orthogonal polarization capability that newer ENG systems already have. By using polarization selector switches on the ENG vans at locations with multiple receive sites, there can be sufficient spatial/polarization isolation to allow for simultaneous transmissions on a given ENG channel. Potentially, this allows ENG operators in the large markets to at least double the channel capacity of BAS ENG operations in areas which require more channels than are available without frequency re-use.

In summary, digital video compression and transmission equipment can be dynamically configured, in terms of encoded bit rates, modulation schemes, and error correction code rates, to best suit the program material and transmission environment. This inherent flexibility allows for transmission bandwidths to be readily changed, therefore making it possible to develop a wide range of rechannelization plans within the 85 MHz of spectrum at 2025 - 2110 MHz.

AFFIDAVIT

We hereby certify that we are the technically qualified persons responsible for the preparation of the engineering information contained in the Appendix, that we are familiar with the technical characteristics of the digital and radio communications systems described in the Appendix, that we have either prepared or reviewed the engineering information submitted in the Appendix, and that it is complete and accurate to the best of our knowledge and belief.

Diana U. Choi

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Date: May 16, 1997